Climate change susceptibility of rural livelihoods in eastern Ghana

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2010

IVM Institute for Environmental Studies

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Report W-10/12
16 August 2010

This report is released by: VU University Amsterdam – Institute for Environmental Studies

This report was commissioned by:

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Summary

Africa is one of the regions of the world which is potentially most vulnerable to climate change. Although projecting changes in rainfall remains difficult for West Africa, (Hulme *et al.*, 2000;Perret and Bossard, 2008) all models indicate that temperature and potential evaporation will experience in Ghana, and the country is likely to experience a reduction in annual precipitation.

60% of the economically active population of Ghana works in the highly climate-dependent agricultural sector. The country faces environmental problems such as deforestation, overgrazing and soil degradation, which are all related to the overexploitation of natural resources. A decrease in precipitation can be detrimental for the already weak and predominantly rain-fed agricultural sector. In the Dayi River Basin, 87% of the total income is derived from this sector. Inter- and intra-annual climate variability and uncertainty already constraint the agricultural production and thus the availability of a primary source of food, particularly during conditions of drought (Westerhoff and Smit, 2008). Climate change effects are superimposed this. The risk perception of small-scale farmers in rural areas towards climate related hazards is an important source of information to better understand adaptive behaviour and the impact of climate change. This study aims to understand the present-day effects of and responses to climate variability in the Dayi River basin in south-eastern Ghana.

Based on a survey (N=107) it appears that the climate related hazards ‘heat’, ‘drought’ and ‘rainfall variability’ are perceived as highly probable to happen. Important perceived consequences of climate related hazards are a ‘lack of water’, ‘failing harvests’ and ‘outmigration of youth’. Crop failure, hunger and death are the most feared consequences. The respondents state that reforestation, prevention of land degradation, irrigation and planting of tree crops are good adaptive measures, both on a farm scale and on a larger scale. On a farm scale, a diversification of crops is also considered as a good adaptive measure. Outmigration and changing profession are considered as very bad adaptive measures.

The farmers have an above medium risk perception towards climate related hazards. The subsequent motivation of the respondents to adapt is correlated significantly to their experience in farming and on the costs of adaptation. Richer farmers appear more motivated to adapt than the poorer ones.

Official government documents on agriculture and development show only a limited interest in climate change adaptation, and merely focus on development. The development measures that are mentioned in these documents, however, are exactly the topics brought up by the communities. The interrelated degradation of soils and deforestation are important issues in policy documents, as well as the potential of irrigation to stimulate growth of the agricultural sector.

In line with scientific literature this report argues that climate change is just one stressor in a complex environment (Ziervogel and Calder, 2003;e.g. Ziervogel *et al.*, 2006). Adaptation to climate change will therefore only prove useful if it simultaneously deals with important development issues such as environmental degradation and the high vulnerability of the agricultural sector.

1 Introduction

Africa is one of the regions of the world which is potentially most vulnerable to climate change. Although projecting changes in rainfall remains difficult for West Africa, the average temperature is on the rise and so is the potential evaporation (Hulme *et al.*, 2000;Perret and Bossard, 2008). A large share of the African economy is in climate-sensitive sectors (Smith and Lenhart, 1996). West African farming is directly correlated to weather hazards; in fact the estimated farm sector losses will vary between 2-4% of the regional GDP by 2010. Pastoral and agro-pastoral areas will undoubtedly be the most affected by climatic variations (Perret and Bossard, 2008).

Inter- and intra-annual climate variability and uncertainty acts as a constraint to productive agriculture and thus the availability of a primary source of food, particularly during conditions of drought (Westerhoff and Smit, 2008). Generally, climate change impacts are considered against a context of underperforming agricultural systems and a degrading environment in Africa (Magadza, 2003), and adaptation may be slow in forthcoming on this continent (Maddison, 2007).

Through the course of history climate variability became deeply rooted within the West African society(Perret and Bossard, 2008). As climate change effects are superimposed on a complex (agricultural) environment, it is important to see how local communities in different African countries perceive present-day climate related hazards, how motivated they are to adapt to possible changes, and what they do to adapt. The aim of this study is to understand the present-day effects and responses to climate variability. This is a prerequisite for studying the effects and responses to future climate change, and for identifying the key determinants of successful adaptation in the future (Adger *et al.*, 2003). It also reveals potential local barriers to adaptation, and gives an idea of what the local people consider successful adaptation.

This project takes place in the Dayi River basin (Volta Region) in south-eastern Ghana (see Figure 1.1). Research is conducted in five villages that are representative for the three ecological zones that were identified locally. These zones are: the upstream forested north of the basin, the midstream transitional savannah and the downstream mountain range.

This research in Ghana follows from the ADAPTS project, funded by DGIS of the Netherlands ministry of foreign affairs. ADAPTS aims to increase developing countries' adaptive capacities by achieving the inclusion of climate change and adaptation considerations in water policies, local planning and investment decisions (See www.adaptation.nl).

This report is composed as follows. Chapter 3 describes the method used. In chapter 4 describes the present-day environment and climate, and the projected climate change. The baseline socio-economic situation of the inhabitants of the Dayi River is described in chapter 5. Chapter 6 combines the outcomes of chapters 4 and 5, and gives an overview of the likely impacts of climate change on the farmer households in Ghana. The following Chapter 7 describes the households' risk perception towards climate related hazards, and chapter 8 shows the adaptive measures that people already undertake, or think about. This information of these two chapters is based on field observations and a survey conducted in May and June 2009. The last chapter provides a summary and a conclusion, as well as recommendations for further studies and policies.

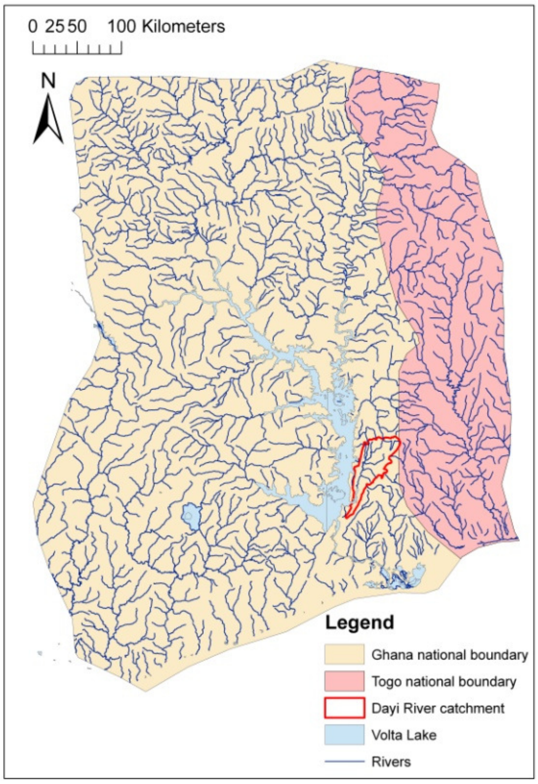

Figure 1.1 The project area (right) in Ghana, close to the Togo border (left).

2 Method

2.1 Risk perception leads to adaptive measures

The perception of communities towards climate change have become an important challenge in understanding climate-society interactions (Meze-Hausken, 2004), as the objective ability or capacity of what a human actor only partly determines if an adaptive measure is taken (Grothmann and Patt, 2005). The risk perception of farmers towards hazards is reflected in changes and adaptations of different farming strategies, and in changed behaviour in general (Meze-Hausken, 2004;e.g. de Wit, 2006;Maddison, 2007). A high risk perception motivates a farmer to act, based on his experience, local conditions and means to do so. After adaptive measures are applied they are evaluated and, if successful, repeated, up-scaled to other parts plots, or copied by neighbours or other entities. Unsuccessful measures can be altered or abandoned, for instance because they are too expensive, too labour-intensive, too time consuming, cause erosion or other negative effects on the environmental, are not suitable at the longer term, etc. The farming system is always subject to changes, especially in areas under high climate variability, such as the research areas in Ghana. Therefore, the suggested visualized process is iterative and incremental (See Figure 2.1).

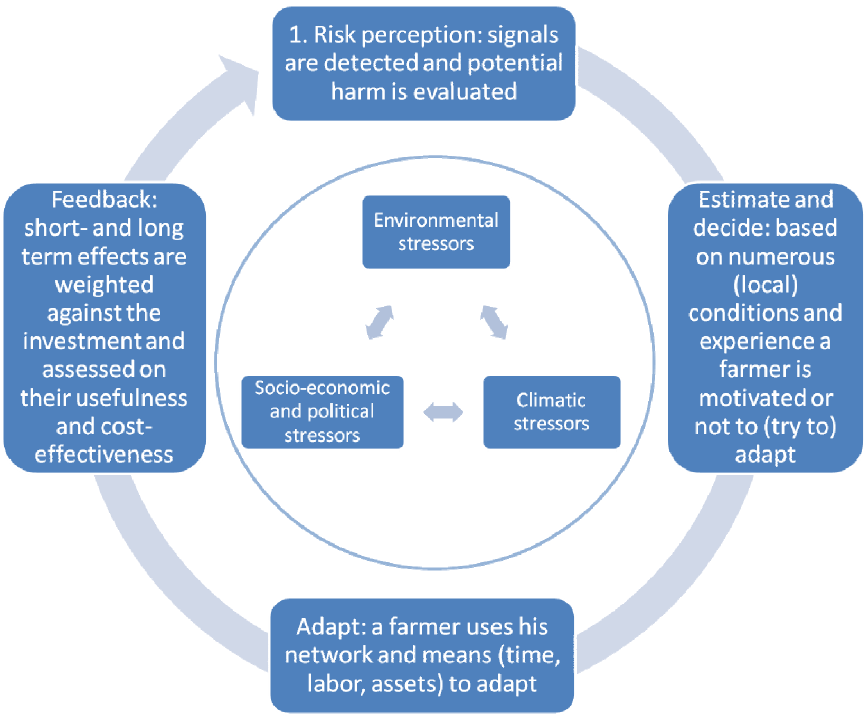

Figure 2.1 The process of risk perception and adaptation is iterative and incremental.

For a researcher, in this complex situation it is essentially impossible to specify or develop appropriate and applicable adaptation measures without detailed knowledge of the research location and the community (Smit and Pilifosova, 2003). For policymakers, the understanding of farmer perceptions regarding long-term climatic changes, current adaptation measures and their determinants is also important to stimulate future successful adaptation of farmers (Nhemachena and Hassan, 2007;Patt and Schröter, 2008;Deressa *et al* ., 2009;Bryan *et al.*, 2009).

For this research 107 interviews were conducted to ask local subsistence farmers about their socio-economic situation, risk perception towards climate related hazards, motivation to adapt, adaptive measures taken and, for example, means to recover from a hazard.

2.2 Survey set-up and sampling procedure

Because it is intended to repeat this study in three years, the interviews are largely quantitative. The response format of the questionnaire consisted of mainly closed questions. Many questions used a Likert scale from 0 (no, not at all, not important, etc.) to 6 (very high, very severely, very important, etc.). Open questions were only added to go in more depth on some issues. For some questions, people were asked to explain their answer.

The questionnaire consisted of three parts. First, questions on socio-economic and demographic characteristics, such as education, income, water use, assets, etc. were asked. Second, a range of questions on, *inter alia*, chances and consequences of climate related hazards, experience, dependency, voluntarism, equity and expectations led to an overview of the communities' risk perception. Third, a set of questions on recovery, available resources, motivation, feasibility, etc. created an overview of the willingness and means of people to adapt to climate related hazards. Altogether, the interviews lasted for 45-75 minutes.

The exact field study area is selected based on discussions with representatives from the regional office of the Ministry of Food and Agriculture (MoFA) and Development Institute (DI). Five villages were selected based upon their representativeness for the three most distinct ecological zones in the basin. The villages of Have and Woadze represent the mountainous downstream area. Koloenu represents the mid-stream transitional savannah, where forests are largely cleared and turned into large scale arable land. Lipke Kukurantumi and Lipke Abrani represent the upstream forested area.

In all five villages a spatial probability sampling method was used: households were randomly picked for administered face-to-face interviewing. The interviewers hired interpreters to pose the questions in local languages, if necessary. Both the face-to-face interviewing and the spatial probability sampling are likely to have lead to minor deviations in the sample. Response rates were 100%.

2.3 Climate change versus climate related hazards

The research fields of climate change and disaster risk have been separated due to uncertainty about the role played by climate change in determining disaster risks caused by extremes in climate variability (Schipper and Pelling, 2006).However, understanding the present-day effects and responses to the impact of climate variability is a prerequisite for studying the effects and responses to future climate change, and for identifying the key determinants of successful adaptation in the future (Hulme *et al*., 2000;Adger *et al*., 2003). It also reveals potential barriers, and could give an idea of what successful adaptation actually is. Besides these theoretical considerations, a more practical consideration was that people are not or hardly informed about climate change[1], but do experience climate related hazards such as droughts and changing seasons regularly. Therefore, it was decided to ask people

[1] For example, people in the field said that the trees that used to guide the winds have been cut, and claimed that this chased away the rains. If asked about climate change, they only said that at night it is too hot to sleep.

about their adaptation to climate related hazards, even though the project's interest is in adaptation to climate change. We opted for climate related hazards in stead of natural disasters, as the latter also include non-climate related hazards, such as tsunamis and earthquakes.

2.4 Conclusion

The perception of communities towards climate change is an important challenge in understanding climate-society interactions, as the objective ability or capacity of what a human actor only partly determines if an adaptive measure is taken. Conducting a quantitative survey allows to compare different answers and to get an overview of the local situation. A Likert scale was used to compare different climate related hazards; open questions were used to go into more detail on some issues. The respondents were asked on their experiences with climate related hazards, as it appeared that people in the case study area are unfamiliar with climate change. Understanding the present-day effects and responses to the impact of climate variability is however a prerequisite for studying the effects and responses to future climate change, and for identifying the key determinants of successful adaptation in the future.

3 Climate change and the environment

3.1 Climate

Ghana has a tropical climate with a dry season from November to April and a bimodal wet season that shows peaks in June and September. Runoff of rivers is equally marked by high variability between wet seasons and dry seasons (Andah *et al* ., 2004). The annual rainfall in the study site is far above the African average, but decreased from 1700 mm/year in 1975 to 1400 mm/year at the present. This decline is most noticeable from March to June and in November; the rainy season shortened (See Fig. Figure 3.1). In entire Ghana, lower rainfall amounts over the years due to longer dry seasons have led to more and more tributaries and main rivers drying up quickly, leading to a lower surface and groundwater availability for the increasing population (Andah *et al* ., 2004).

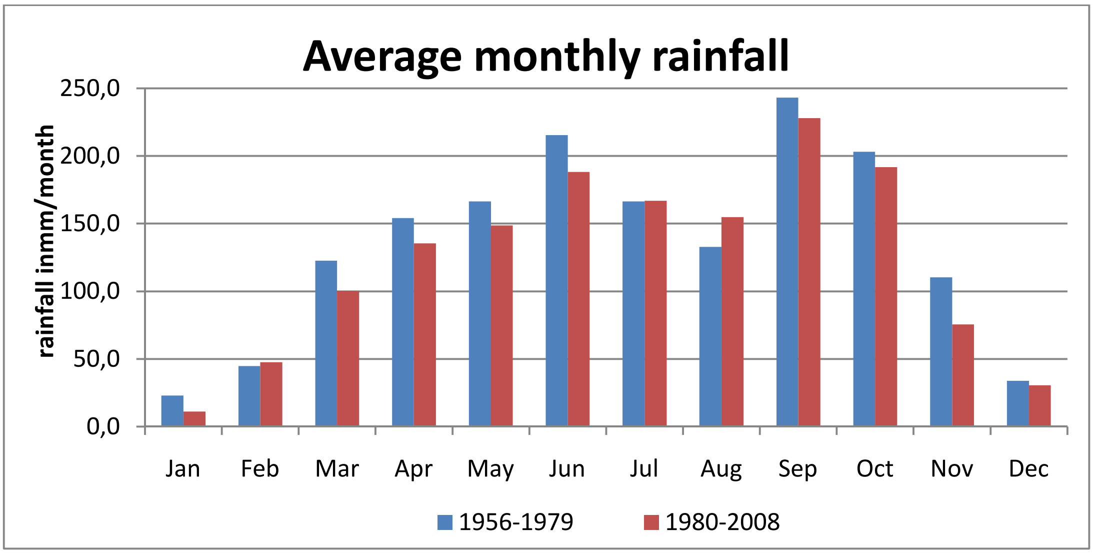

Figure 3.1 Average monthly rainfall in Hohoe, Dayi River basin (WRC database).

At the same time, the mean annual daily temperature has increased by 1°C in the period 1961-2000 (Westerhoff and Smit, 2008), and is projected to increase by 2.5-3.0 °C by 2050 (IPCC, 2007). A recent projection from the Netherlands Climate Assistance Programme (NCAP) indicates a further decline of rainfall and a shortening rainy season, combined with increasing temperatures throughout the year (Agyemang-Bonsu *et al* ., 2008).

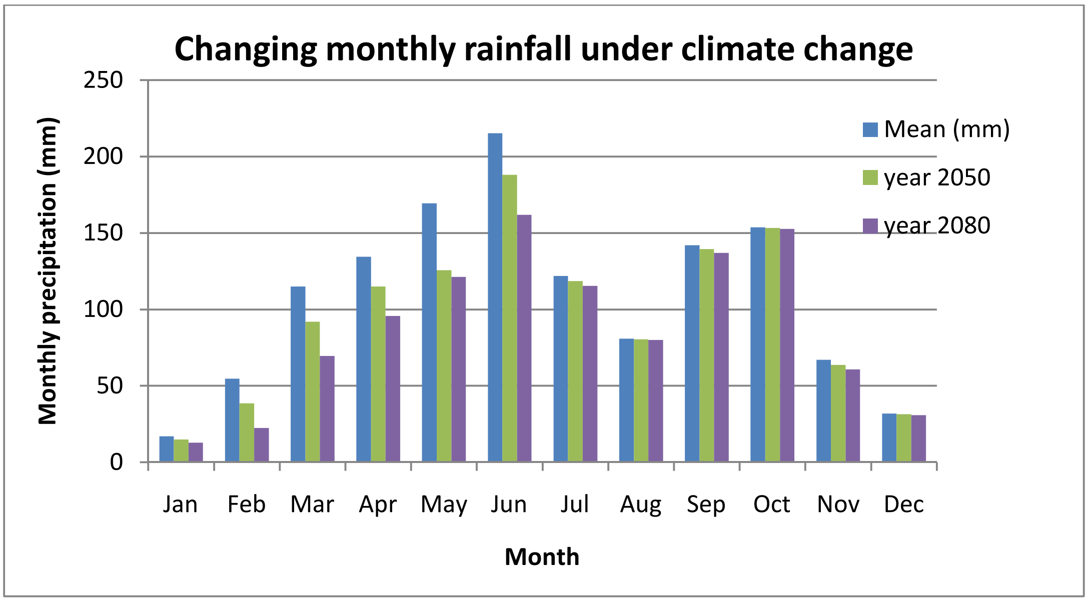

Figure 3.2 Projections of changes in rainfall made by NCAP, for the medium scenarioin southern Ghana (deciduous forest area)(Agyeman-Bonsu et al, 2008).

Models used by the IPCC, however, project an overall increase of precipitation in Ghana in the case study region, although it must be said that there is little consistency in the 21 models shown (Solomon *et al* ., 2007). Precipitation projections generally contain some inconsistencies for Africa, explained partly by the inability of GCMs to reproduce the mechanisms responsible for precipitation including, for example, the hydrological cycle and account for orography. Furthermore, they are also explained partly by model limitations in simulating the different teleconnections and feedback mechanisms which are responsible for rainfall variability in Africa (Boko *et al* ., 2009).

3.2 Deforestation and degradation and climate change

Ghana faces environmental problems such as deforestation, overgrazing, soil erosion, soil degradation, poaching, and habitat destruction, which are all related to the overexploitation of natural resources (Griebenow and Kishore, 2009). The resulting land degradation has been a major threat to the estimated 150.000 km^2 agricultural land in Ghana. Since the 1990s, degradation became a major development issue in terms of its impacts on poverty alleviation, food security and economic growth. At the present, 69% of the total land surface area of Ghana is affected by moderate to severe erosion, coming at an average cost of 2% of GDP (Ministry of Food and Agriculture, 2008).

In addition, recurrent droughts and climate change, inducing increased rainfall variability and an overall drop in precipitation, are affecting the agricultural productivity. Likewise, the predicted rise in average temperatures will make forest and savanna areas more prone to fires, further increasing the vulnerability of rural areas to the effects of climate change (Griebenow and Kishore, 2009). Climate change impacts in Ghana will therefore increase the vulnerability of the poor (Griebenow and Kishore, 2009).

3.3 Impact on the case study area

The Dayi River basin is also facing large scale deforestation. LANDSAT images show that deforestation intensified after 1987. However large-scale erosion is not visible and deforestation does not seem to have had a large impact on river flows and the local climate.

A majority of the respondents state to face prolonged dry seasons and rainfall variability every two to three years. The main cause people mention for this are deforestation and bushfires, and some people also blame it to unhappy gods. Nine (prolonged dry season) and thirteen respondents (rainfall variability) state that these are just the natural conditions. Only 6 respondents mention that rainfall variability might have something to do with climate change.

Although prolonged dry seasons and rainfall variability are not allocated to climate change by the respondents in this research, this chapter shows that climate change impacts and degradation are strongly related when it comes to the vulnerability of respondents to climate related hazards.

4 Socio-economic and demographic situation of households

4.1 Introduction

Ghana is a low-income country with a population of 23 million inhabitants and a per capita gross national income of US$ 510. For the past two decades the country has had steady economic growth, giving it a good chance of becoming a middle-income country in the next decade (Griebenow and Kishore, 2009). Its economy is largely based on agricultural sector. The poor performance of the agricultural sector is often said to be at the core of the growth problem in Ghana as a whole and hence the need to seriously tackle the structural problems of the sector (Ghana Statistical Service, 2005). This chapter provides an outline of socio-economic and demographic situation of the households interviewed for this study.

4.2 Agriculture

The agricultural sector in Ghana drives much of the country's social and economical development with its contribution of over 35% of GDP, its account of 75% of export earnings and its contribution of more than 90% of the food needs of the country (Ministry of Food and Agriculture, 2008). The Dayi River basin lies within the Volta Region, in which almost 60% of the economically active population works in the agricultural sector. They cultivate around 29.0% of the total arable land of the region. The major agricultural products include cocoa[2] and staples such as maize, rice, sorghum, cassava, yam, cocoyam and plantain. The cultivation of non-traditional crops like black pepper, cashew nuts, ginger, pineapple, pawpaw and mangoes, meant for export, are on the increase (Ghana Statistical Service, 2005).

Irrigation

Irrigated farms in Africa have a higher average net revenue per hectare than dryland farms (Kurukulasuriya *et al* ., 2006). Although the Volta Region is strategically located next to the largest of Ghana's freshwater sources (the Volta River and Volta Lake) irrigated agriculture is yet to be exploited (Ghana Statistical Service, 2005). Currently, informal irrigators that do not depend on public infrastructure for their water supplies dominate the bulk of irrigated output in Ghana. Fetching water with watering cans and buckets is dominant, while motorized pumps and hoses are also used along the streams and reservoirs (Ministry of food and Agriculture, 2006). A lack of recognition of this irrigation-subsector has resulted in typical constraints, such as limited access to credit and tenure insecurity. As a consequence, there is hesitation to invest in infrastructure (Ministry of food and Agriculture, 2006).

4.3 Case study area

The Volta Region has a population density of 79.5 persons per km^2 and a population growth of 1.9% after correction for out-migration. Unemployment rates are 7-8%, but at them same time 83% of the economically active population works in the informal private sector. In total, around 80% of the economically active population is self-

[2] The region used to be a major cocoa growing area. The cocoa industry made Hohoe a very important commercial town and it was the capital of the Trans-Volta Togoland. It caused considerable in-migration from northern Ghana to the northern districts of the region. The cocoa industry has however declined over the years as a result of various agronomic and political problems. Immigration turned into outmigration.

employed, and because the population is rather young (41% is aged 0-14 years), the dependency ratio is high: 92 dependents on 100 working people (Ghana Statistical Service, 2005).

The Dayi River basin largely lies within the Hohoe Municipality, with smaller parts in Jasikan and Kpandu Districts. Based on consultation at the regional office of the Ministry of Food and Agriculture (MoFA), five villages were selected for conducting a survey. These villages are selected because they are representative for the three major ecological zones in the river basin: the upstream forest (the villages of Kukurantumi and Abrani), mid-stream transitional savannah (Koloenu) and down stream mountain range (Woadze and Have, see Table 4.1).

Table 4.1 Villages selected for fieldwork in thre ecological zones in the Dayi River basin.

Ecological zone	Position in river basin	Community	Features
Forest (N=35)	Upstream	Kukurantumi, Abrani	Tree-cropping (cocoa production), Dayi River as main water source
Transitional savannah (N=35)	Midstream	Koloenu	Grasslands, forest zone, vegetables cultivation, area interspersed by rivers
Mountain range (N=37)	Downstream	Woadze, Have	Uphill agriculture, deforested hill slopes, root crop production predominant

4.3.1 Socio-economic situation

A typical households has one male and one female member, and two to four children (see Figure A-1). Most respondents see themselves as farmers, although there are many who also have other sources of income. Selling food products and selling commodities are the most common among these; ten respondents also state to get remittances or a pension.

In the questionnaire ten yes/no questions were posed on a number of indicators of socio-economic welfare (see Figure 4.1). Clearly the list is incomprehensive and the outcome is not solely based on the actual economic situation but rather on a myriad of underlying influences including social, historical and day planning components, such as inheritance, number of children, distances to roads, kinship, etc. However, the list does elucidate some differences between the three ecological zones.

It becomes clear that nearly all households in each zone possess footwear, different sets of clothes, and a brick build house. Furthermore, most of them are able eat three times a day and to pay the school fees for the children. When it comes to owning the house, some first differences arise. The four remaining indicators clearly show that the midstream households are best off; a higher percentage of respondents have a telephone, money for holidays and health insurance. Over half of them also have means of mobility; the downstream households even rank higher. It is clear that the upstream households have the lowest scores; they seem to have the lowest socio-economic development level. They are also least educated: 65% of the respondents only have primary or middle schooling (versus 59% of the midstream respondents and 45 of the downstream respondents).

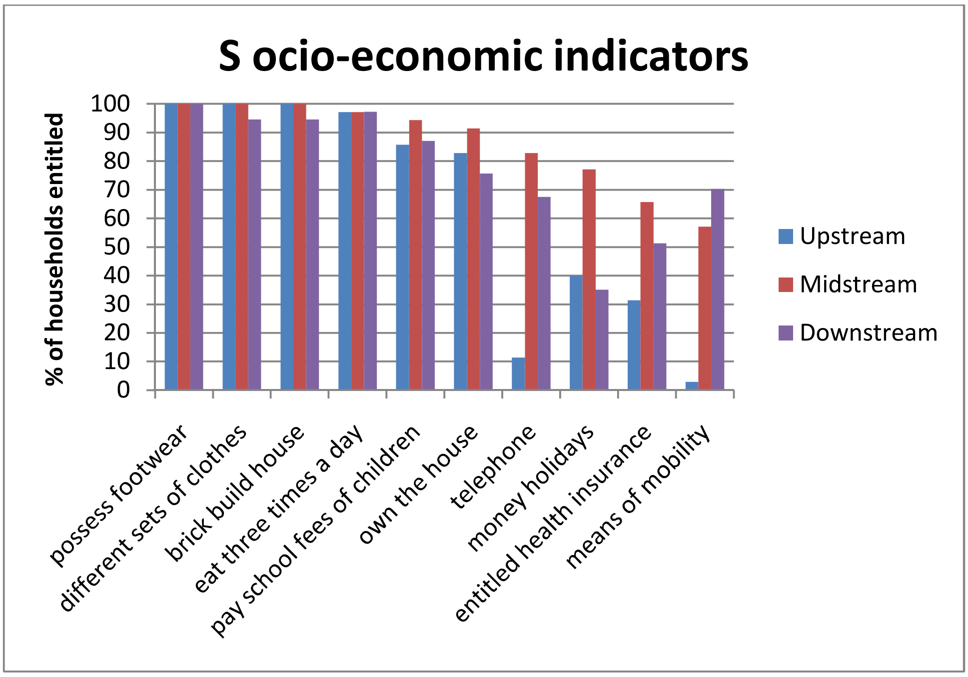

Figure 4.1 Indicators of socio-economic welfare in the upstream, midstream and downstream ecological zones, based on the survey results (N=107).

4.3.2 Water use

Although all villages are connected to the water net, only 30.7% of them uses pipe water as their main source of domestic water. The reason is that they have to pay for this water. A large majority (50.4%) of the respondents fetches water directly from the river, as this is for free. 8.7% uses water from a pump, and 6.3% from a well.

4.3.3 Agricultural output and income

Only 6 out of 107 respondents irrigate actively; the amount of irrigated land constitutes 3.47% of the total agricultural land being used (excluding fallow land). Thirty-one respondents however grow irrigated crops, 17 of which live in the midstream zone. Unlike the harvests of the tree crops and the rain fed crops, virtually the entire harvest of irrigated crops is used for commercial purposes: 99% of the 96160 kg is sold on the market. The most important crops are Okra (39660 kg), garden eggs (32480 kg) and pepper (17520 kg). Of the 66040 Ghana Cedis revenue, 50305 are earned by the 17 midstream farmers. The total value of the harvest is correlated significantly to the amount of land under cultivation (R^2=0.255). Large differences in profitability however exist, due to 1) the location of land that influences the soil fertility or moisture content; 2) the diversity of crops cultivated and their type (root crop, vegetables, tree crops or rice); 3) the ability to use land management techniques such as fertilizers (Rozema, 2009).

Many more respondents grow rain-fed crops such as cassava (80.4%) and maize (77.6%). Of the harvest of rain fed crops, 15.6% is used for own consumption and the rest is brought to market. The production of beans, rice and peanuts is almost exclusively the domain of the midstream households; they also grow most of the maize produced. The more drought resistant crops of Cassava, yam and cocoyam are grown more by the upstream and downstream communities.

Tree crops are mostly grown for commercial production by the respondents. Palm nuts, plantain and bananas are the most important products. The former two are mainly grown by the midstream respondents, but in total the value of the harvest of the upstream respondents is the highest.

With 4.17 different crops per respondent, the midstream households grow the largest number of different crops (the downstream and upstream respondents grow 2.46 and 3.34 different crops, respectively). The harvests of the midstream households have by far the highest value and the revenues are the highest. The value of the total harvest and the number of crops grown correlate significantly: R^2=0.401 [3]. Much of it this is based on good water availability, but on crops that are sensitive to drought, such as tomatoes, okra and garden eggs.

[3] Obviously the two are related, and scientific literature also shows that a diversification of the crops grown is a good measure to adapt to climate change, but this does not necessarily mean that one can see his of her income increase when one starts cultivating more crops. As a matter of fact, maize, rice and beans make up 53% of all revenues. It also depends on the amount of land under cultivation (which correlates significantly with the number of crops grown as well, R^2=0.106)

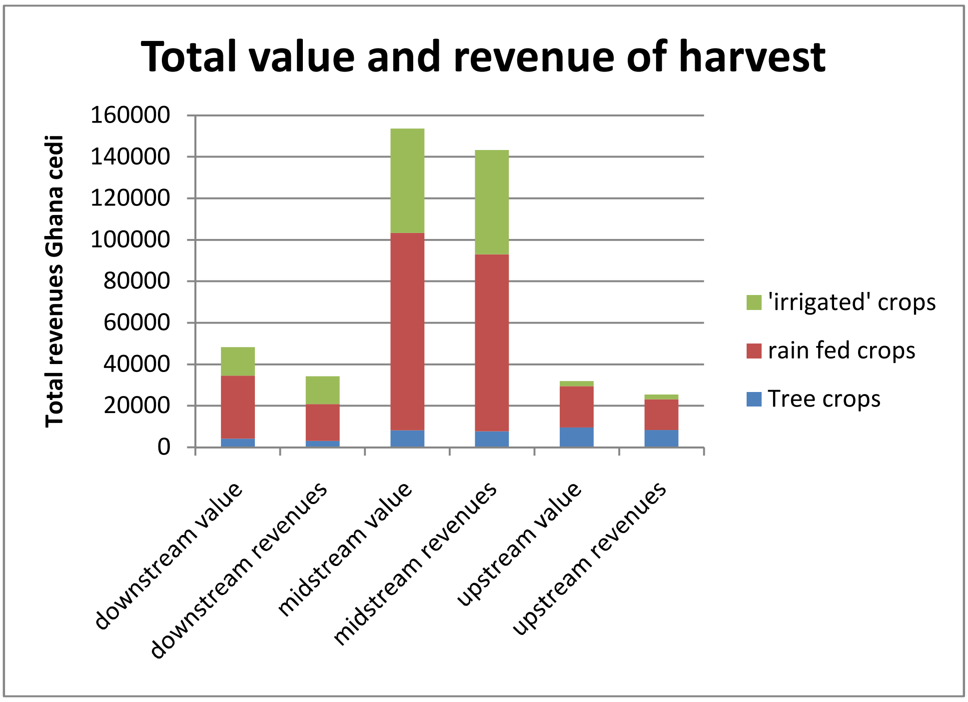

Figure 4.2 Total value of respondents' harvest (based on stable market prices) and the revenues based on what respondents actually sell. It clearly shows that farmers are selling the larger part of their harvest. The midestream farmers grow and earn the most by far. Based on the soil characteristics they are also able to grow irrigated crops without irrigation.

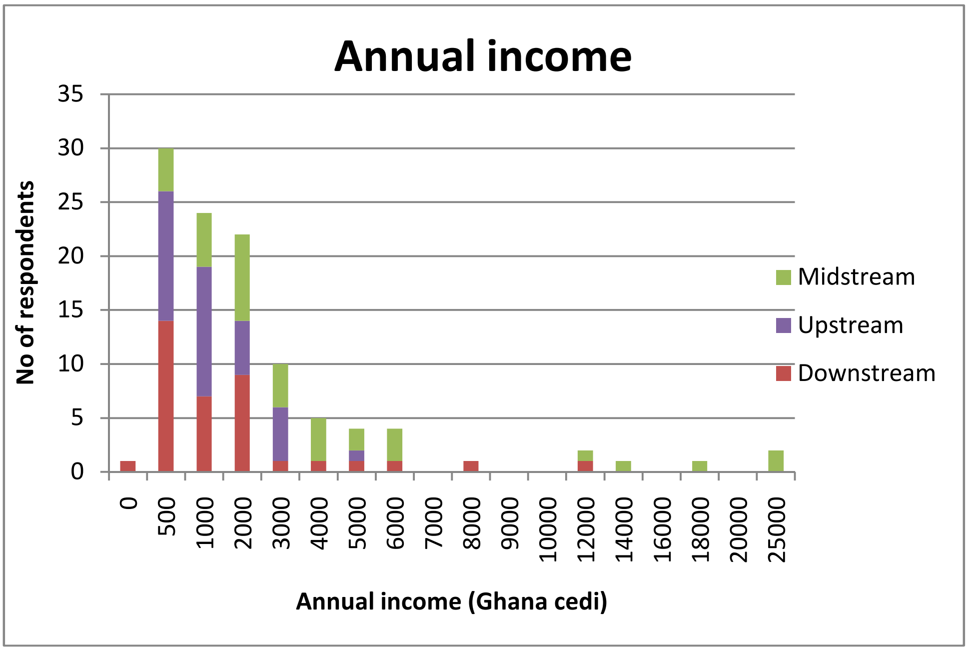

Figure 4.3 Annual income per respondent, largely based on the revenues of agricultural output.

Fifty respondents (47%) have additional sources of income generation, such as processing food, selling fish and eggs, selling livestock, or a pension. On average this makes up 25.4% of the overall income; for fourteen respondents it makes up more than 50%.

A large majority (ranging from 57% upstream to 72% downstream) states that their income has decreased in the past five years (See Figure 4.). They argue that price fluctuations have decreased the market prices of their crops and increased the price of seeds or pesticides and (inorganic) fertilizers. Some people have fallen ill because of poor health or age and therefore could not maintain their living standards (Rozema, 2009).

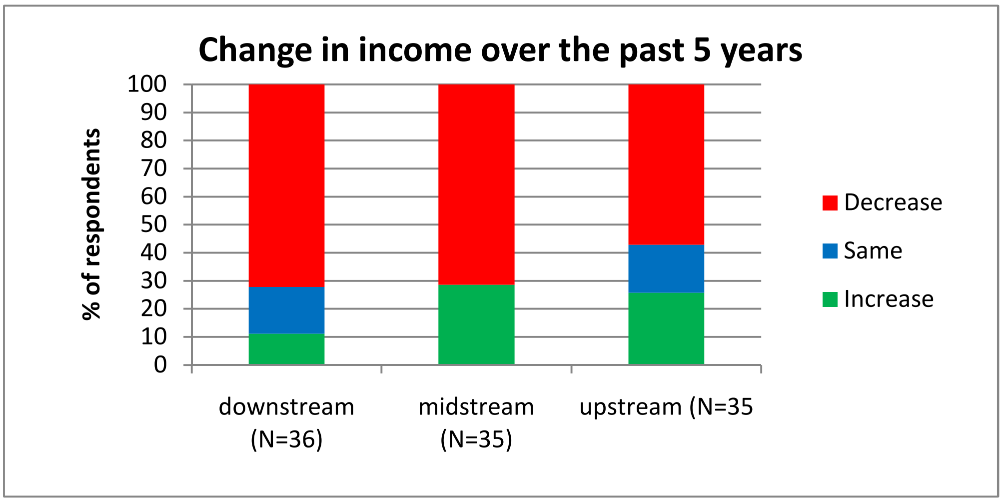

Figure 4.4 Change in income over the past five years.

5 Impact of climate related hazards

5.1 Introduction

Land degradation, desertification and soil erosion hit hardest at the local level and those most affected are the poor, women and other vulnerable groups who depend on natural resources for their survival (Ministry of Food and Agriculture, 2008). Climate change is a threat superimposed on the existing problems. As 57.9% of the economically active population of the Volta region has their livelihood in the natural resource dependent agricultural sector, it is important to look at the vulnerability of the agricultural sector towards climate change.

5.2 Agriculture

Currently only 29% of the total arable land of the Volta Region is under cultivation. The major agricultural products include cocoa and staples such as maize, rice, sorghum, cassava, yam, cocoyam and plantain (Ghana Statistical Service, 2005). Root crop (e.g. cassava, yam and cocoyam) yields in Ghana are positively and highly significantly correlated to total rainfall. Since irrigation is often not an option or not practiced, farmers have become completely dependent on the precipitation and have to adjust their farming patterns after the rain periods (Agyemang-Bonsu *et al* ., 2008). In general, water resources play a vital role in the promotion of economic growth and the reduction of poverty in Ghana, and water demand is increasing rapidly (Andah *et al* ., 2004). As the precipitation is likely to decrease due to climate change, it has the potential to degrade soil and water resources and subsequently subsistence agricultural production (Agyemang-Bonsu *et al* ., 2008).

The decrease in the amount and reliability of rains impact rain-fed agricultural practices and other natural resource dependent livelihoods in the region. This amplifies the negative effects of shifting agricultural practices and population growth that already led to over-harvesting of wood, bush fires and ultimately land degradation (Agyemang-Bonsu *et al.*, 2008).

5.3 Effects on the case study area

A large majority of the respondents in all villages state to encounter prolonged dry seasons and rainfall variability every 2-3 years. For all three ecological zones, crop failure is the most mentioned effect of a prolonged dry season (56 respondents in total). Hunger comes second (although only mentioned five times in the downstream area). Compact soils (total of 31 respondents), illness (30) and lack of water (22) are also major effects. Poverty and heat are also mentioned more than ten times.

Crop failure is also the most mentioned effects of rainfall variability (79 times in total). Hunger scores high here as well (again with low numbers in the downstream area) as it adds up to 33 respondents. Illness is mentioned 34 times and poverty nine times. In the upstream area, twenty respondents state that one of the effects of rainfall variability is that houses collapse. Only four respondents in the other villages mention this.

5.4 Conclusion

Climate change amplifies already existing environmental problems in the natural resource dependent agricultural sector in the case study region. The major climate related hazards here are prolonged dry seasons and rainfall variability. The most important effects is crop failure, which can be detrimental, given the fact that people not only grow food for household consumption, but also determines over 80% of the respondent's (mostly low) incomes, whilst irrigation possibilities do not or hardly exist up to date.

6 Risk perceptions towards some climate related hazards

6.1 Introduction

Risk is often described as the probability of an event, multiplied by its consequence. Communities are susceptible to multiple stressors; climatic stimuli are in fact just one stressor in a complex environment (Ziervogel *et al.*, 2006;Westerhoff and Smit, 2008). The *relative* risk perception therefore expresses the perceived probability of being exposed to climate related hazards and to the appraisal of how harmful the impact would be to things an actor values (consequences), compared to the relative appraisal of other problems or challenges in the actor's life (Grothmann and Patt, 2005). Risk perception thus entails much more than just the perceived probability and the consequences of an event (Slovic, 1987;Sjöberg, 1998;e.g. Grothmann and Patt, 2005;Patt and Schröter, 2008). This chapter describes the risk perception of the communities towards climate related hazards based on various indicators.

6.2 Perceived chances and consequences

For prolonged dry seasons, rainfall variability, droughts and heat, the midstream community has the lowest perception of the probability of it to happen, and the downstream communities have the highest perception. For floods on the other hand, the midstream respondents have the highest perception of the probability. In the overall picture, the probability for heat is by far the highest (4.02 on average; SD=1.17)[4], followed by rainfall variability (av. 3.54; SD=1.04), droughts (av. 3.39; SD= 1.29) and prolonged dry season (av. 3.27; SD= 1.05). The probability of a flood is considered as low (2.13; SD= 1.57)(See Figure 6.1).

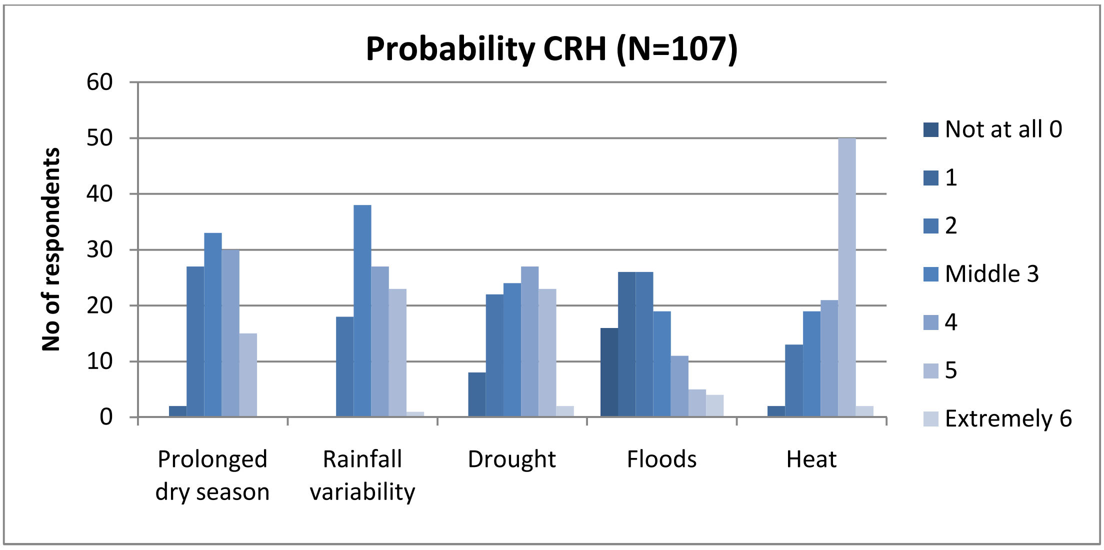

Figure 6.1 Probability of five climate related hazards for all respondents taken together.

The average perception of future probabilities of the same five climate related hazards is quite similar to the perception of the present-day probabilities. The only major

[4] The most important outcomes of questions with a Likert scale are given in Annex B in averages, standard deviations, medians and modes.

difference is the perception of rainfall variability: respondents stated the probability to be 0.26 lower on the Likert scale. However, on a community level or even an individual level, there are larger differences. The downstream respondents perceived the future risk of flooding to go up, whereas the other respondents all thought it would go down. The net difference between the average future perception of the probability of drought and the present-day average perception is virtually zero, although the upstream communities perceive the probability to go up by 0.439 on the Likert scale.

Most consequences of climate related hazards score 3 to 4 on the Likert scale on how important the consequences of climate related hazards are (See Figure 6.2). Overall, outmigration of youth is considered the most important (average 4.56; SD= 1.05), followed by a lack of water (average 3.93; SD= 1.18) and failing harvests (av. 3.89; SD= 0.93). Obviously the three are interrelated. A lack of water can lead to failing harvests, which in its turn can lead to outmigration of youth, when they look for an income elsewhere. Soil erosion is considered less important, and changing cropping seasons are considered to be of mediocre importance[5]. Within the perceptions of consequences there is much more variety than in perceptions of probabilities. For example, the downstream respondents score much lower than average on outmigration of youth and consequences of water shortage, but score highest on changing cropping seasons. For the other four consequences the midstream respondents score highest.

The perceived future consequences are slightly different of the present-day perceptions. Except for the consequences of erosion, all effects are perceived to go up. Most noticeable are the consequences of outmigration of youth (+0.25) and water shortages (+0.33)[6]. The midstream respondents have the highest perception of the consequences for all five categories.

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[5] This is interesting. According to the IPCC, climate change will cause seasons to change (Boko *et al.*, 2007), which could lower lake and stream levels, or stunt, wilt and/or infest crops (Westerhoff, 2008). The farmers however do not perceive changing cropping seasons as a major problem, at least not at this stage.

[6] This is largely due to the perception of the respondents in the downstream area: they score +0.49 and +0.55, respectively.

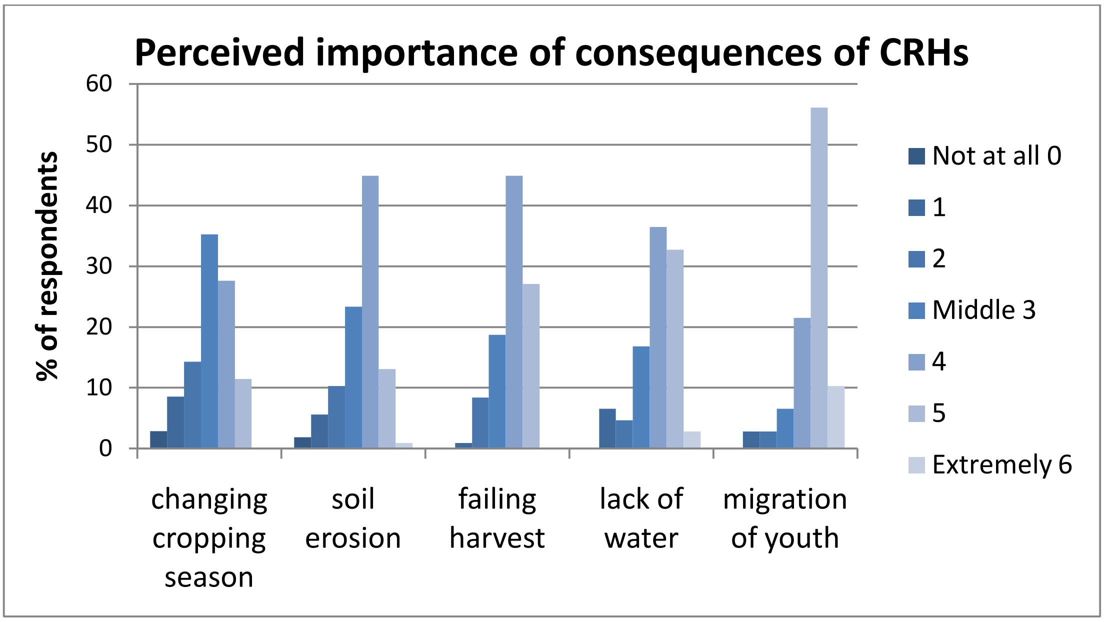

Figure 6.2 Perceived importance of some of the likely consequences of CRHs for all respondents.

Respondents state to be both highly dependent on the climate (the average for all three areas is in the order of magnitude of 4.2), and to be relatively vulnerable to climate related hazards (averages of 3.7 for both midstream and upstream, and 3.9 for the downstream respondents). In fact the two correlate significantly for the entire sample (N=107): R^2 is 0.31 and for the downstream respondents: R^2=0.63. For the midstream and the upstream households they do not correlate (R^2=0.02 and R^2=0.11, respectively).

Despite the fact that the midstream communities perceive the consequences of CRHs as most important of the three regions, they are least afraid of climate related hazards. Both the upstream and downstream respondents average 4.3 (SDs are 1.47 and 0.92 respectively), although it must be said there is a clearer visible peak (uniformity) among the downstream respondents. The midstream respondents state to be medium afraid of CRHs. In an open question, 91 respondents stated that hunger is the most feared effect of CRHs. Death is mentioned by nine respondents; six upstream and three downstream.

6.3 Conclusion

According to the respondents in the case study area, the most probable climate related hazards are an unbearable heat to work, rainfall variability and drought. They consider a lack of water, a failing harvest and the subsequent outmigration of youth as the three most important consequences of climate related hazards. Hunger is seen as the worst consequence of climate related hazards by 85% of the respondents; 8% considers death as the worst potential consequence.

The respondents consider themselves as dependent on the climate, as well as vulnerable to climate related hazards, and afraid of future hazards.

7 Adaptation

7.1 Introduction

Climate change can have very serious negative impacts on the socio-economic development of Ghana if no appropriate adaptive measures are identified and put in place (Andah *et al.*, 2004). Adaptation refers to responses by individuals, groups and governments to actual or expected climatic stimuli or their effects to reduce vulnerability of adverse impacts or damage potential, or to capitalize opportunities brought about by climate change. People will need to adapt, either because the local impacts of climate change leave them no alternative, or because specific adaptation will reduce the losses associated with those impacts substantially (Patt and Schröter, 2008). Farm-level decision making occurs over a short time period usually influenced by seasonal climatic variations, local agricultural cycle, and socio-economic factors (Nhemachena, 2008), and therefore adaptive measures are usually focused on short-term measures.

In Ghana, it is likely that climatic change driven water shortages in key growing stages of crops will pose the biggest threat on the present-day livelihoods of subsistence farmers. Measures to improve the water availability can be either demand driven or supply driven. For example, measures like introducing new crop varieties, mulching and improving the efficiency of irrigation systems reduce the demand for water (Smit and Skinner, 2002;e.g. Gbetibouo, 2009). Irrigation and construction of small rainwater storage are examples of supply driven adaptive strategy that can greatly enhance livelihoods (Pauw *et al.*, 2008). In Ghana irrigation is seen as the most important way of using water for poverty reduction is through the development of irrigation (Ministry of food and Agriculture, 2006). For a large overview of available adaptation measures in the agricultural sector, see for example Nhemachena (2008), Smit and Skinner (2002) and the World Bank (2009).

However, whilst deliberating available options for adaptation, one should also recognize that ccommunities are susceptible to multiple stressors. Climatic stimuli are in fact just one stressor in a complex environment (Ziervogel *et al.*, 2006;e.g. Westerhoff and Smit, 2008). Furthermore, non-climatic conditions may amplify or exacerbate climate-related risks, or they may dampen, counteract or overwhelm the climatic effects (Smit and Skinner, 2002). Therefore, both for identification and implementation of adaptive measures, but also to understand the factors of success or failure, one needs a thorough understanding of the community and local conditions.

7.2 Policies and public adaptation

In the joint publication of the Ghanaian Environmental Protection Agency (EPA) and the Netherlands Climate Assistance Programme (NCAP), it is written that afforestation/reforestation within the degraded forest lands will be encouraged. In their studies in other parts of Ghana it also appeared that farmers perceived deforestation to be the cause of the irregular rains and the degraded soils (Agyeman-Bonsu *et al.*, 2008; 227). The EPA furthermore states that alternate cropping could be encouraged. This practice allows farmers to change cropping systems. For instance farmers in the Akumadan areas of Ashanti Region who used to grow cocoyam now grow vegetables which are short duration crops, and cereals like maize. Members of Boekrom (Western Region) also grow more of cassava than cocoyam and yam because of lack of good soils (Agyeman-Bonsu *et al.*, 2008; 227). There are also some official government programmes:

Agriculture and sustainable land management strategy and action plan 2009-2015 (2008)

Although this strategy is not directly focused on adaptation, it promotes some development measures that do improve sustainability and address the root causes of land degradation, thereby reducing the vulnerability towards climate change. It shifts from the traditional conservation strategy to more resource management as a whole. For that purpose, land management should be made an integral part of all agricultural development planning and implementation. Although strategies such as awareness creation, development of community land use plans, and mainstreaming of sustainable land and environmental management are supported by guiding principles such as sustainability, biodiversity conservation and prevention/protection/rehabilitation, it fails to look at climate change as an inherent part of future land management. However, some climate change adaptation related activities are planned, such as conducting trainings to extensions services providers and demonstrate best practices in adaptation to farmers.

Draft national irrigation policy (2006)

According to the Draft national irrigation policy water is a cross-cutting thematic issue for improving livelihood improvement in Ghana. Irrigation is seen as the most important way of using water for poverty reduction is through the development of irrigation (Ministry of food and Agriculture, 2006). Therefore, awareness and sensitization are one of the guiding principles of the policy, to generate demand for irrigation by communities that are aware not only of the benefits of irrigation and their obligations as users of public sector infrastructure, but also the need for a well enforced regulatory framework. The irrigation policy is not just supply driven: water saving techniques are also promoted as a strategic action. Water allocation and quality are also considered, but not structurally addressed in terms of possible temporal or spatial shortages. At the same time, neither climate variability, nor climate change are mentioned as one of the reasons for implementing an irrigation policy.

7.3 Autonomous adaptation

Quite some studies on farmer or micro-level adaptation in different parts of Africa have been published recently (Nhemachena and Hassan, 2008;Hassan and Nhemachena, 2008;Gbetibouo, 2009;Deressa *et al.*, 2009;e.g. Bryan *et al.*, 2009). Obviously, adaptation in agriculture vary with respect to the climatic stimuli to which adjustments are to be made, and according to differing farm types and locations, and the economic, political and institutional circumstances in which the climate stimuli are experienced and management decisions are made (Smit and Skinner, 2002). As it is often difficult to distinguish what measure is actual adaptation and what is not, a myriad of measures can be recalled. However, a number of measures stand out more than others. Changing crop varieties and types, and changing the amount planted are fairly typical responses of farmers towards changing climatic conditions (Ziervogel *et al.*, 2006;Nhemachena and Hassan, 2007;Deressa *et al.*, 2009).

The present-day socio-economic development can no longer depend on rain-fed agriculture under climate change, and therefore increased irrigation is sometimes promoted as the way forward (e.g. Andah *et al.*, 2004;Kurukulasuriya *et al.*, 2006). According to them, small-scale irrigation has good potential even on the short term as it does not need huge investment. Apart from these climate change related recommendation, the Ghana Statistical Service (2005) already wrote that agricultural workers need to be assisted to enable farmers to acquire and implements small-to-medium scale irrigation equipment to facilitate farming throughout the year (Ghana Statistical Service, 2005). In other words: irrigation seems to be a direct way for both development and adaptation to climate change.

7.4 Case study area

It is interesting to see that respondents on average think that their farming practices differ much from their neighbours' farming practices. Almost 84% of the respondents think this reduces the risk of climate related hazards.

Respondents state to have a medium experience in coping with CRHs: the overall average is 2.80 (SD=1.41). Based on their experience, respondents in all three regions state that the cost-effectiveness of coping with CRHs is high (average scores vary from 4.33 downstream to 5.06 midstream). Although adaptation is considered to be reasonably cost effective, respondents do not all state to have the means to cope with climate related hazards. The respondents in the midstream region state to have an average means, but the upstream respondents score below two on average. The downstream respondents even below one (average is 0.97; SD= 1.30); in fact 44% of the respondents state to have no means at all to cope with climate related hazards. The respondents perception of their means to adapt significantly correlates to their annual income (R^2=0.216)

The means that respondents have also correlates significantly with their perception of the controllability (R^2=0.221). Experience also correlates significantly with the controllability (R^2=0.218). Respondents however give very diverse answers on how controllable climate related hazards are. This could be caused the inaudibility of the question, or because respondents refer to different things whilst answering this question. The overall average however inclines towards little controllability (the average is 2.31, SD=1.48). The most often mentioned constraints to controllability are a lack of money (23 times, mainly in the downstream community), a lack of tree crops (6 times), the inability to irrigate and a shortage of land (both 4). The most mentioned factors that improve the controllability are good land management (20 times), tree crops (14), pray to gods (6), and intercropping, prevention of bushfires/deforestation, irrigation and buffer zones (all 5 times).

Respondents state to have average recovery ability, although it must be said that both the downstream and midstream answers are scattered over the 7 answering categories. The respondents from the three regions are however uniform in their answer on how many subsequent years they can recover from CRHs: two to three years[7].

7.4.1 Adaptive measures

Respondents were first asked what kind of measures they would take to cope with CRHs, and than about their perception of or experience with the effectiveness of several predefined adaptive measures. They were asked to do so for both individual and collective measures.

The adaptive measures most respondents came up with were reforestation (77 in total, equally spread over the three zones), preventing bushfires and deforestation (ten in total, of which eight in the upstream zone), irrigation (nine in total, of which 8 in the downstream zone) and planting tree crops (6) and pray to gods (6). Apart from the latter all these measures can repeatedly be found in scientific literature as well.

[7] It must be said, however, that 41 respondents did not know the answer to this question.

Of the predefined individual measures, the diversification of crops[8] (average 4.51; SD=1.03) and irrigation (average 4.65; SD=0.85) are perceived as highly successful in all three zones. Second best are changing crops and changing planting dates, although they score below average: 2.58 and 2.43, respectively. The more drastic measures of changing profession (average is 1.14, SD=1.59) and outmigration (average is 0.18, SD=0.67) are very unpopular and not considered as successful. This demonstrates that the respondents prefer to stay in agriculture.

The collective measures that respondents came up with most, are reforestation again (83 times, equally divided over the three zones), prevent bushfires and deforestation (twenty; twelve of which in the upstream zone), law enforcement (8); pray to gods (6) and education (5). Planting of tree crops and irrigation, quite popular under the individual measures, were both only mentioned four times.

The collective measures, all score surprisingly and significantly higher on the Likert scale than the individual measures. All measures have a peak at 'very much (5 on the Likert scale). According to the respondents, the most effective measure is education (average of 5.05; SD=0.74). Nature conservation, irrigation, buffer zoning and micro credit all score between 4.8 and 4.9 as well; insurance has the lowest score, which is still 4.56 (SD=1.00). It is interesting to see that the downstream communities score lowest on all community measures.

Motivation to adapt

The respondents indicate to be highly motivated to adapt, both individually and as a community. The overall individual score is slightly higher (4.16 vs. 4.03). The individual motivation is based on the perceived experience and cost-effectiveness of the adaptive measures (R^2=0.133 and 0.130, respectively), and also correlates significantly to the respondents' means (R^2=0.088) and calculated total income (R^2=0.059). It therefore comes as no surprise that the upstream respondents score highest on individual motivation (4.29, SD=1.08). They however score lowest on community motivation (3.74, SD=1.14).

7.5 Conclusion

Ghana, the case study area included, is susceptible to climate change, but potential adaptive measures are being developed, or can be developed. The government documents show some interest in climate change adaptation but climate change is never the starting point. The main focus is on development and poverty alleviation. The interrelated degradation of soils and deforestation are important issues in policy documents, as well as irrigation. These are or can be adaptive measures as well.

Exactly these topics are also brought up by the respondents, both in open and closed questions of the questionnaire. Reforestation, prevention of land degradation, irrigation and planting of tree crops are seen as good measures to prevent the negative effects of climate related hazards, both for individuals and communities as a whole. Crop diversification is also stated to be a successful measure to cope with climate related hazards.

The respondents' motivation to adapt is correlated significantly to their experience in farming and on the costs of adaptation. Richer farmers appear more motivated to adapt than the poorer ones and are, in line with Slegers (2008) better able to adapt.

[8] The perceived successfulness of diversification of crops significantly correlates with the number of different crops respondents grow (R^2=0.083). for both indicators the midstream community scores highest.

8 Conclusion

Ghana will experience an increase in temperature and evaporation, and is likely to experience a reduction in annual precipitation. As 60% of the people in Ghana are in the highly climate-dependent agricultural sector, the country is very vulnerable to climate change. In the case study area, even more people are dependent on agriculture and 87% of the total income is derived from agriculture.

Ghana already faces large-scale environmental problems such as deforestation, overgrazing, soil erosion, soil degradation, poaching, and habitat destruction, which are all related to the overexploitation of natural resources. In fact land degradation is a major development issue in terms of its impacts on poverty alleviation, food security and economic growth. At the present, 69% of the total land surface area of Ghana is affected by moderate to severe erosion, coming at an average cost of 2% of GDP (Ministry of Food and Agriculture, 2008).

Climate change is superimposed on the effects of degradation on agricultural productivity. A decrease in precipitation can be detrimental for the predominantly rain-fed agricultural sector. At the same time, it is difficult to increase the productivity of rain-fed agriculture mainly because investments in labour or agro-chemicals do not pay off when the rains fail (Andah *et al.*, 2004). Likewise, the predicted rise in average temperatures will make forest and savanna areas more prone to fires, further increasing the vulnerability of rural areas to the effects of climate change (Griebenow and Kishore, 2009). Climate change impacts in Ghana will in that sense increase the vulnerability of the poor.

The respondents in the case-study area were asked about their experiences with climate related hazards that are likely to increase in occurrence and severity. They think that ‘heat’, ‘drought’ and rainfall variability’ have a high probability to happen. Important consequences of climate related hazards are a ‘lack of water’, ‘failing harvests’ and ‘outmigration of youth’. The most feared impact of climate related hazards are crop failure, hunger and death.

The respondents state that reforestation, prevention of land degradation, irrigation and planting of tree crops are good adaptive measures, both to be taken on a farm scale and on a larger scale. On a farm scale, a diversification of crops is also considered as a good adaptive measure. Outmigration and changing profession are considered as very bad adaptive measures.

All in all it can be concluded that the farmers have an above medium risk perception towards climate related hazards. The subsequent motivation of the respondents to adapt is correlated significantly to their experience in farming and on the costs of adaptation. Richer farmers appear more motivated to adapt than the poorer ones.

Official government documents on agriculture and development show only little interest in climate change adaptation, and merely focus on development. The development measures that are mentioned in these documents, however, are exactly the topics brought up by the communities. The interrelated degradation of soils and deforestation are important issues in policy documents, as well as irrigation.

In line with scientific literature this report therefore argues that climate change is just one stressor in a complex environment (Ziervogel and Calder, 2003;e.g. Ziervogel *et al.*, 2006), and that environmental degradation is strongly linked to climate change and climate related hazards.

One remark on this conclusion is that the often locally perceived connection between local environmental problems and climate change is not always correct. Reforestation can be an adaptive measure, for instance because it prevents erosion during heavy rainfall or because it slows down runoff and keeps the soil moisture up. Small-scale local deforestation, on the other hand, is not the cause of global climate change – something many respondents think -, but it can add to a local change in the water availability both on the short and the long term. That in its turn seems to have provoked the perception that the climate has changed, whereas in fact only the local environment changed. The interconnection is clearly there, but not as straightforward as it seems. On the one hand, it is a benefit of risk perception research that the real problems and risks come up, rather than focusing on climate change or CRHs. On the other hand the researcher and the reader should be careful not to mistake climate change effects from local environmental stressors.

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Annex A Extra figures

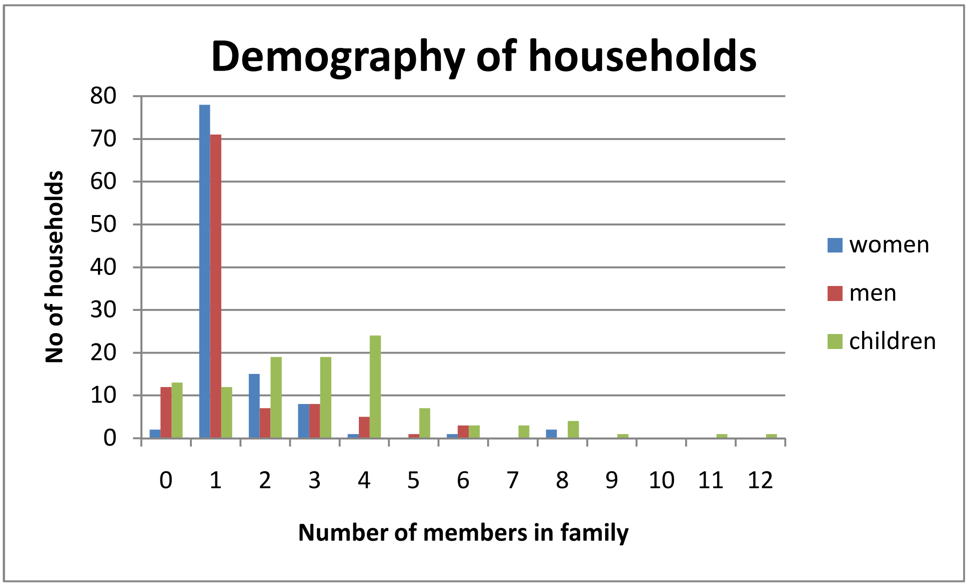

Figure A-1 Demography of the respondent's households: number of households with numbers of male and female members and children

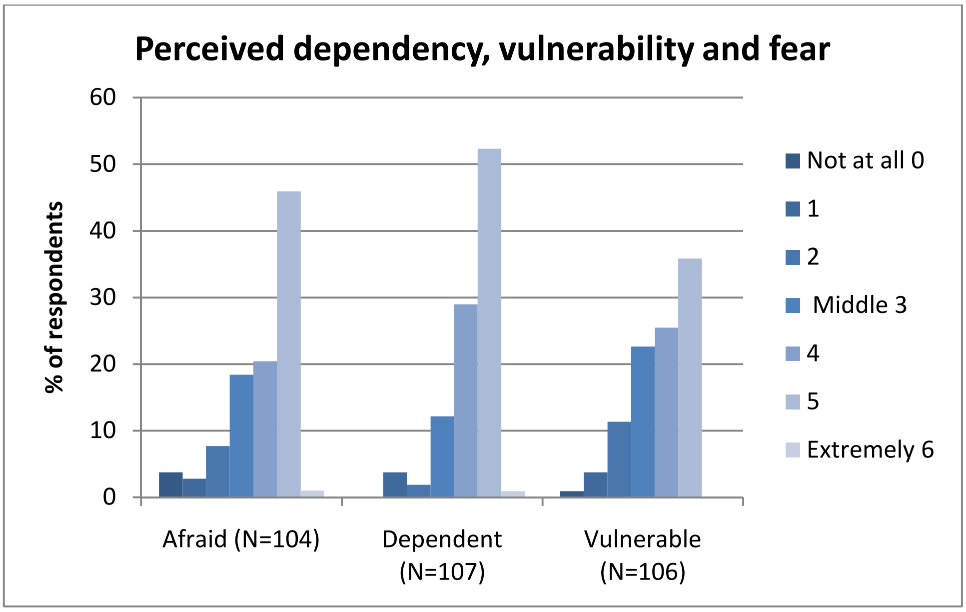

Figure A-2 Perceived fear towards climate related hazards, dependency on the climate and vulnerability towards climate related hazards for all respondents taken together.

Annex B Responses to Likert scale questions (N=107)

	Average	Standard deviation	Median	Mode
livelihoods in agriculture	87%	n.a	n.a	n.a
Income from agriculture	74.6%	n.a	n.a	n.a
Number of crops grown	3.31	1.65	3	3
Hectares under cultivation per farmer	2.07	2.57[1]	1.32	0.81
Climate change vulnerability (based on a Likert scale: not at all (0) to extreme (6))				
Dependency	4.27	1.02	5	5
Vulnerability	3.76	1.22	4	5
Probability heat	4.03	1.18	4	5
-Future probability heat	4.00	1.15	4	5
Probability rainfall variability	3.54	1.04	3	3
-Future probability rainfall variability	3.28	1.19	3	4
Probability droughts	3.39	1.29	3	4
-Future probability droughts	3.38	1.42	4	4
Probability floods	2.13	1.57	2	1
Future probability floods	2.15	1.53	2	1
Consequence: outmigration of youth	4.56	1.05	5	5
Future consequence outmigration youth	4.81	0.84	5	5
Consequence: severity lack of water	3.93	1.18	4	4
Future consequence severity lack of water	4.26	0.99	4	5
Consequence: severity failing harvest	3.89	0.93	4	4
Future consequence severity failing harvest	3.97	0.95	4	4
Consequence: soil erosion	3.47	1.16	4	4
Future consequence: soil erosion	3.39	1.14	4	4
Individual adaptive measures (based on a Likert scale: not at all (0) to extreme (6))				
Education	4.83	0.79	5	5
Change crops	2.58	1.44	3	2
Diversify crops	4.51	1.03	5	5
Irrigation	4.65	0.85	5	5
Change planting dates	2.43	1.43	2	3
Change profession	1.14	1.59	0	0
outmigration	0.18	0.67	0	0
Community adaptive measures (based on a Likert scale: not at all (0) to extreme (6))				
Insurance	4.56	1.08	5	5
irrigation	4.85	0.90	5	5
Nature conservation	4.85	0.74	5	5
Buffer zone around rivers	4.82	0.83	5	5
Micro credit	4.88	1.00	5	5
Adaptation experience (based on a Likert scale: not at all (0) to extreme (6))				
Experience in coping with droughts	2.80	1.42	3	3
Means to cope	1.90	1.39	2	1
Cost-effectiveness of coping	4.63	0.99	5	5
Recovery after a drought	2.98	1.60	3	4
Controllability CRH	2.31	1.48	3	3
Afraid of future droughts	3.90	1.37	4	5
Motivation to adapt	4.16	1.03	4	5
Motivation of community to adapt	4.03	1.03	4	4